New-generation Aura OMI Volcanic SO$_2$ Product: Algorithm Description, Initial Results, and Data Continuation with S-NPP OMPS
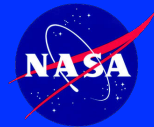
Can Li [1,2], Nick Krotkov [2], Simon Carn [3], Yan Zhang [1,2], Rob Spurr [4], Joanna Joiner [2]

[1]UMD ESSIC, [2]NASA GSFC, [3]Michigan Tech., [4]RTS Inc.

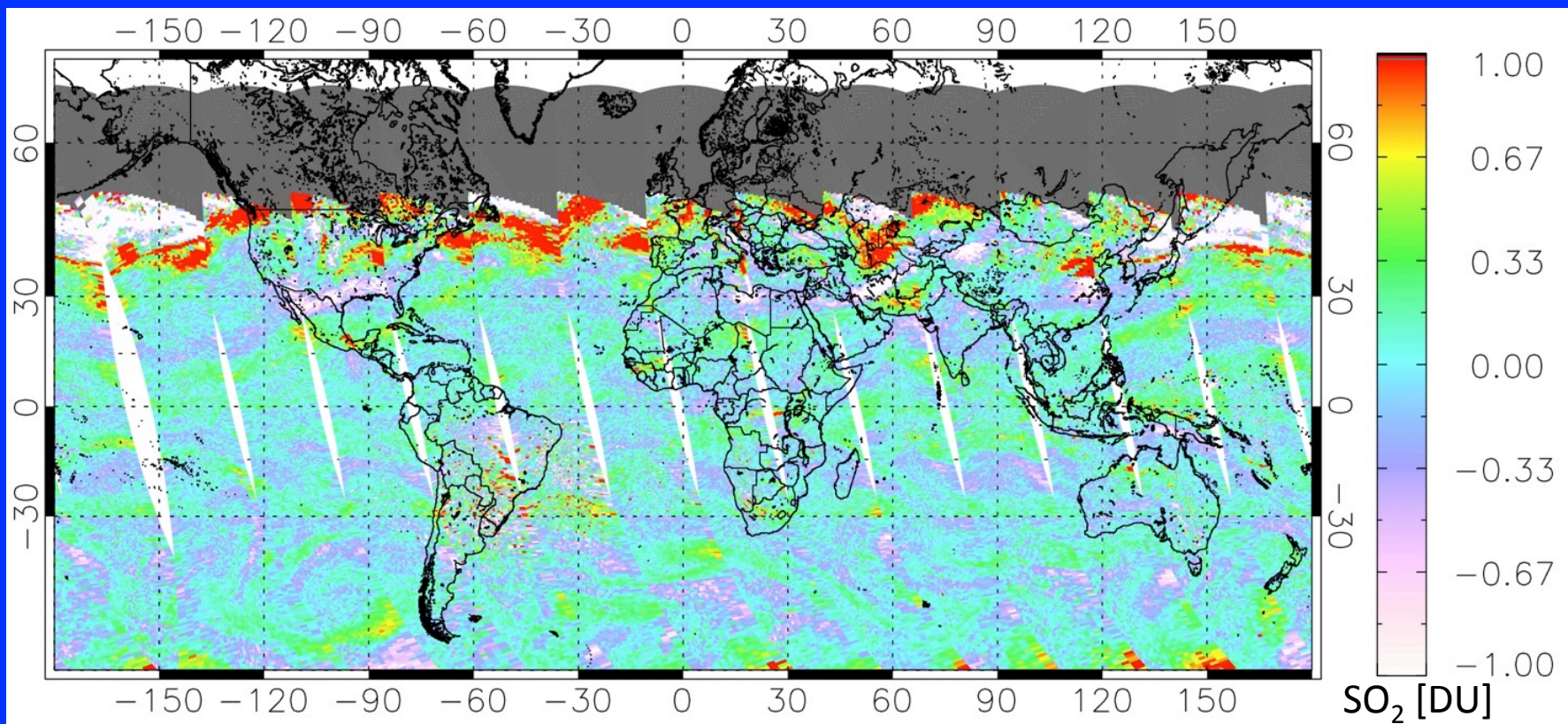Aura Science Team Meeting
August 30, 2016
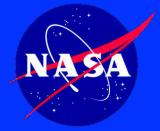Rotterdam, The Netherlands

Why a New OMI Volcanic SO$_2$ Product?

- Previous generation OMI/OMPS volcanic SO$_2$ product: LF algorithm fast and sensitive, but has <u>relatively large noise/biases</u>.
- Also known to <u>underestimate SO$_2$ for large eruptions</u> (*e.g.*, Kasatochi).
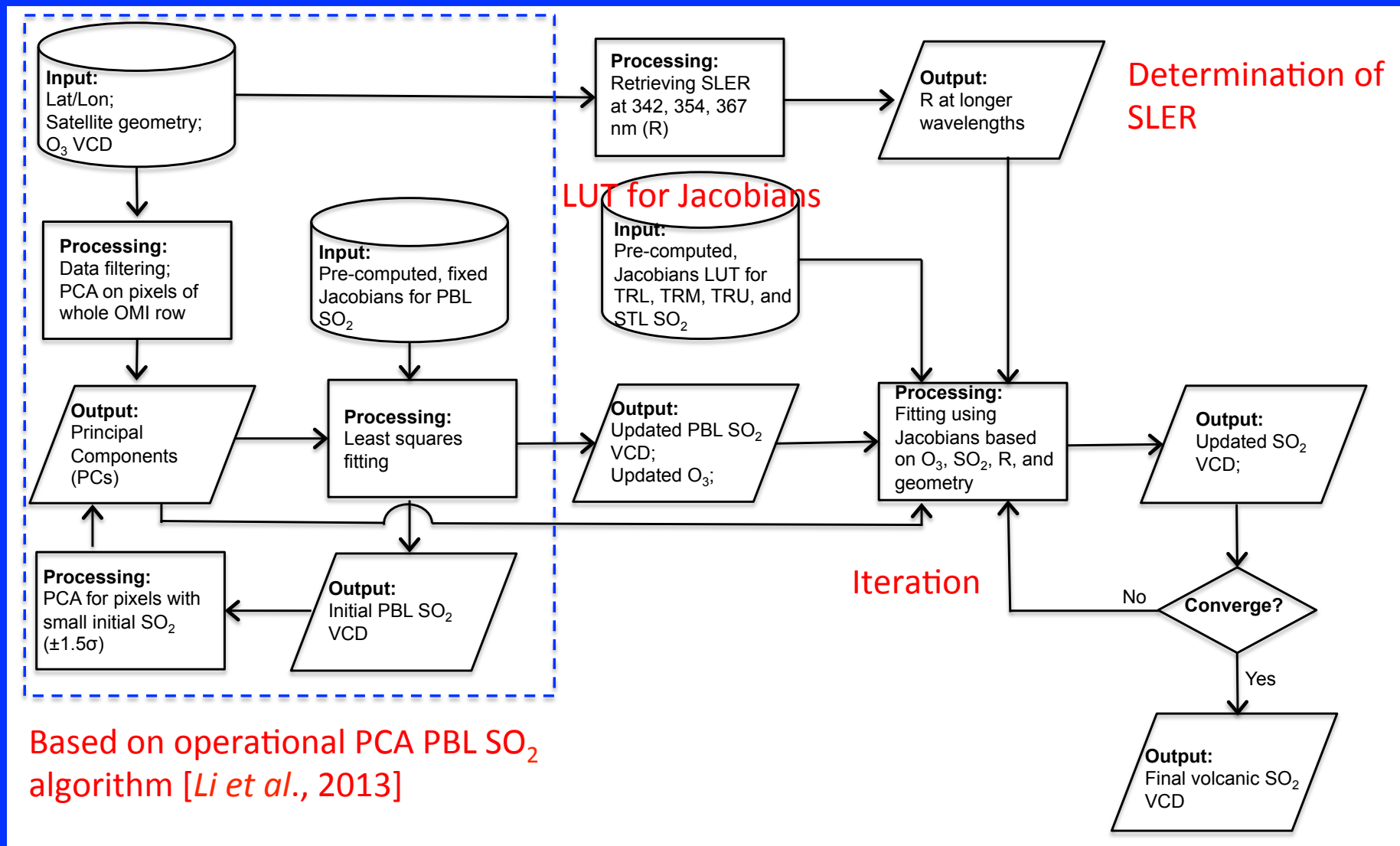

OMPS NRT LF TRL retrievals for 12/08/2015, a few days after the Mt. Etna eruption.
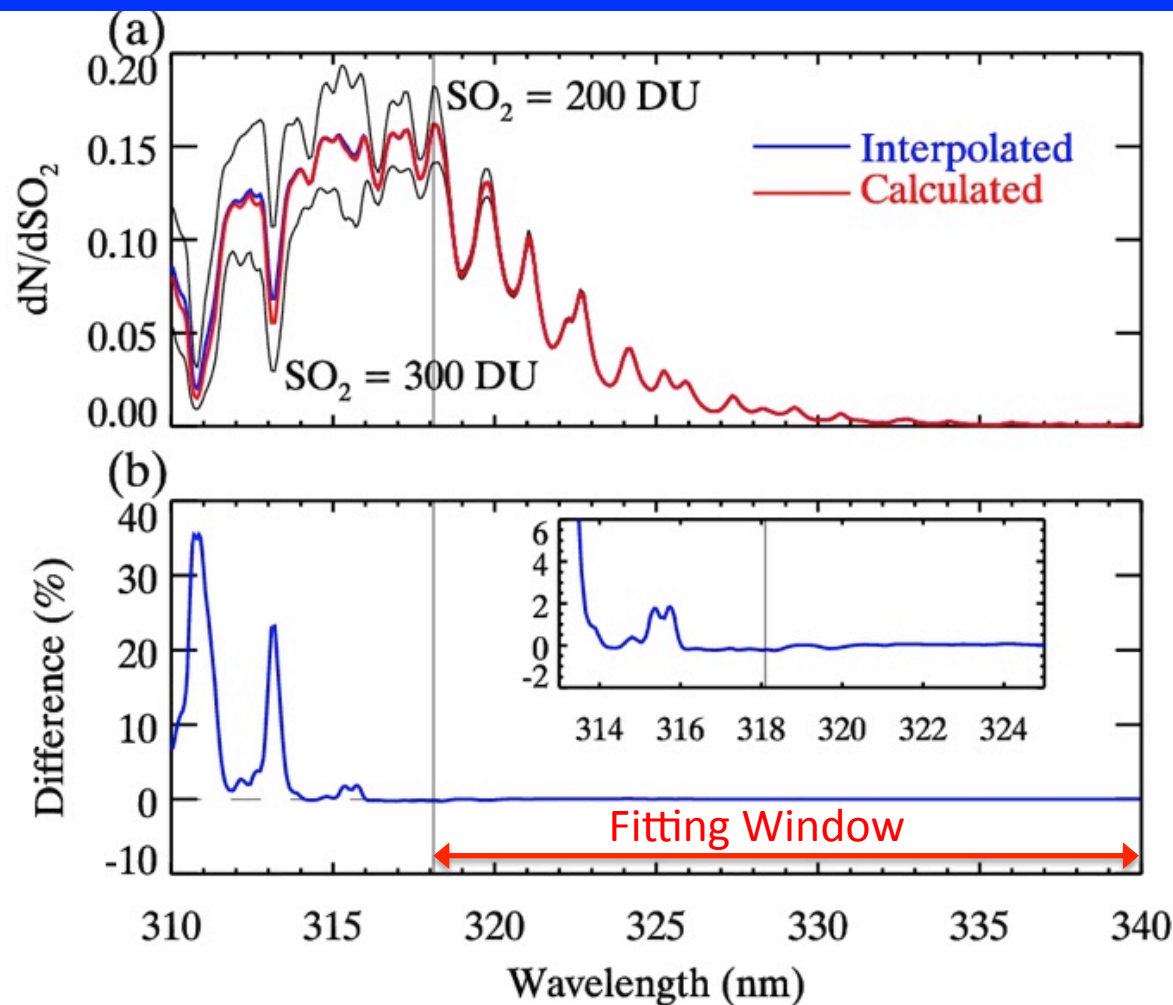
How Do We Improve OMI Volcanic SO_2 Retrievals?

- Based on the PCA approach, using spectral features (PCs) extracted from radiance data in fitting – minimize interferences such as ozone and the Ring effect.

- A lookup table approach for SO_2 Jacobians (geometry, reflectivity, O_3) .

- Predefined SO_2 profiles centered at 3 (TRL), 8 (TRM), 18 (STL) km, also a new research product for 13 km profile (TRU).

- Derive SLER at 342, 354, and 367 nm, extrapolated to SO_2 fitting window – first order effects of aerosols/clouds/surface.

- Iteration – calculate updated SO_2 Jacobians based on SO_2 from the previous step, also determine optimal spectral window in each step.

Algorithm Flowchart

Input:
Lat/Lon;
Satellite geometry;
O_3 VCD

Processing:
Data filtering;
PCA on pixels of whole OMI row

Output:
Principal Components (PCs)

Input:
Pre-computed, fixed Jacobians for PBL SO_2

Processing:
Least squares fitting

Processing:
PCA for pixels with small initial SO_2 ($\pm1.5\sigma$)

Output:
Initial PBL SO_2 VCD

Processing:
Retrieving SLER at 342, 354, 367 nm (R)

Output:
R at longer wavelengths

Determination of SLER

LUT for Jacobians

Input:
Pre-computed, Jacobians LUT for TRL, TRM, TRU, and STL SO_2

Output:
Updated PBL SO_2 VCD;
Updated O_3;

Processing:
Fitting using Jacobians based on O_3, SO_2, R, and geometry

Output:
Updated SO_2 VCD;

Iteration

Converge?

No

Yes

Output:
Final volcanic SO_2 VCD

Based on operational PCA PBL SO_2 algorithm [*Li et al.*, 2013]

- ✓ Large interpolation error in SO_2 Jacobians at short wavelengths – due to the saturation of SO_2 absorption;
- ✓ Use wavelength with max dN/dSO_2 as the lower limit for fitting window in each step;
- ✓ Maximal sensitivity and small interpolation error.

[*Li et al.*, 2016]

New Operational OMI Volcanic SO$_2$ Product Greatly Reduces Bias and Noise over Background Areas
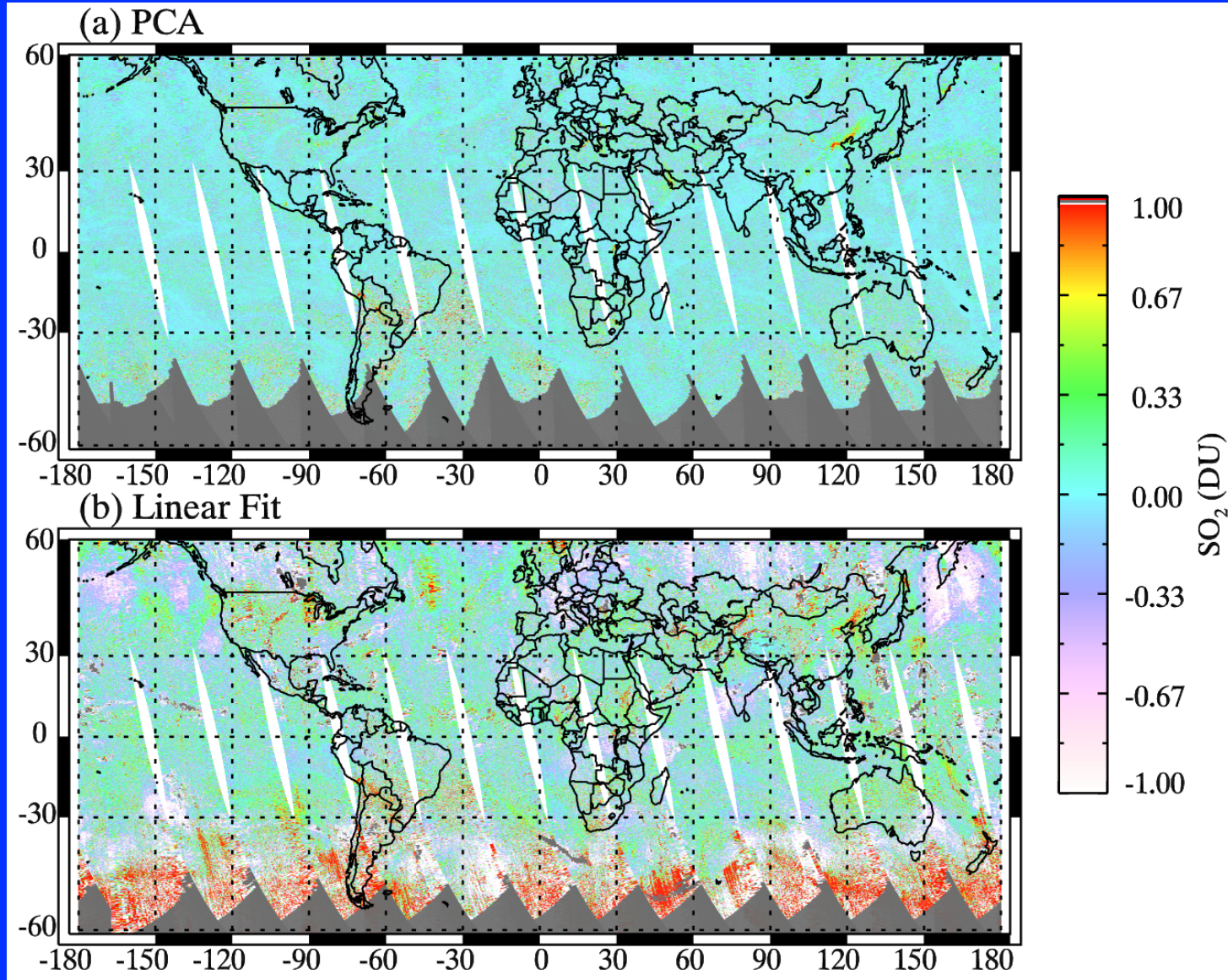
Retrieval noise reduced by a factor of two

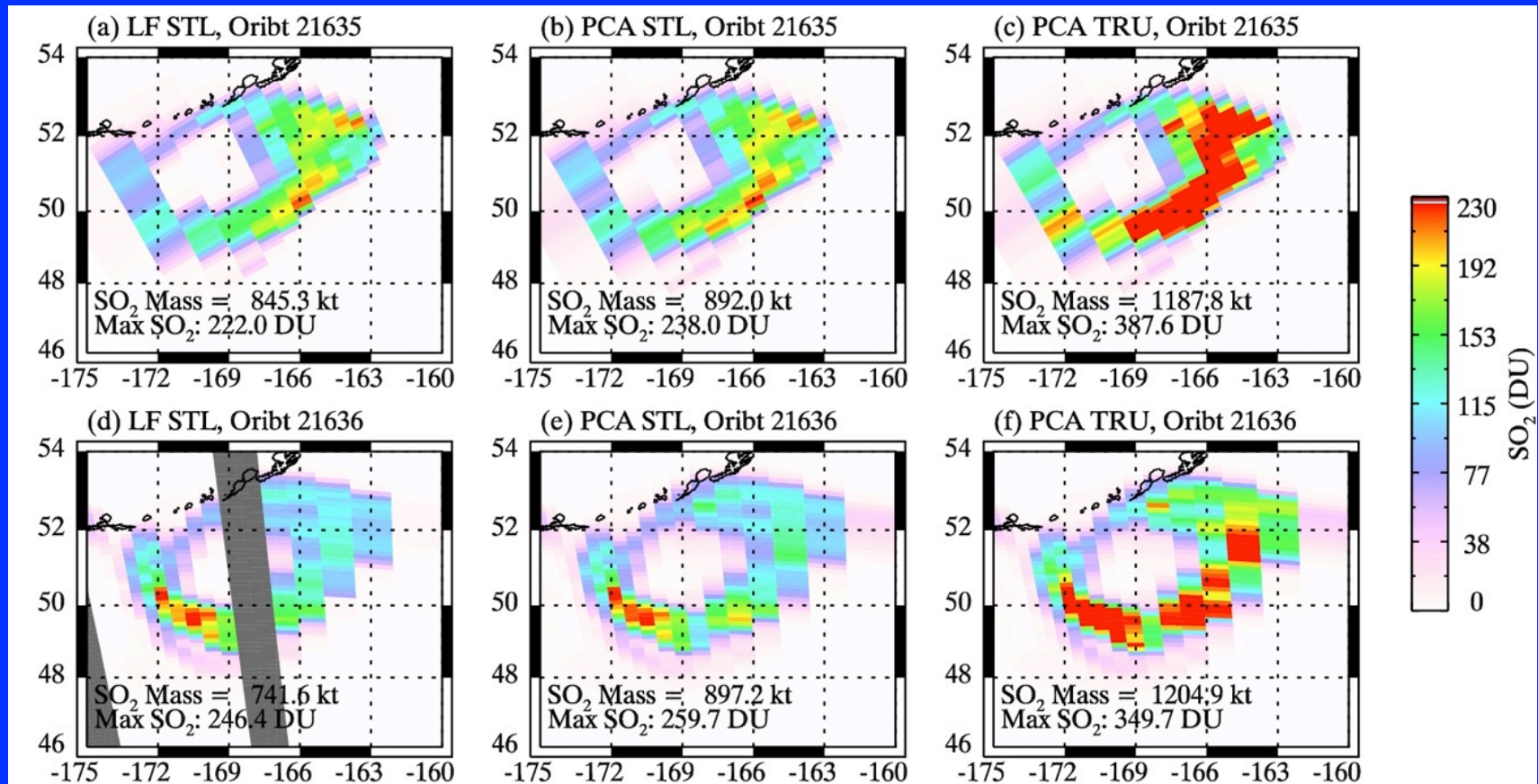TRL Retrievals, August 5, 2006 [*Li et al.*, 2016]
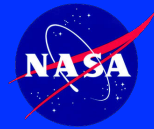
New Operational OMI Volcanic SO$_2$ Product Greatly Reduces Bias and Noise over Background Areas

Retrieval noise reduced by a factor of two over the Pacific
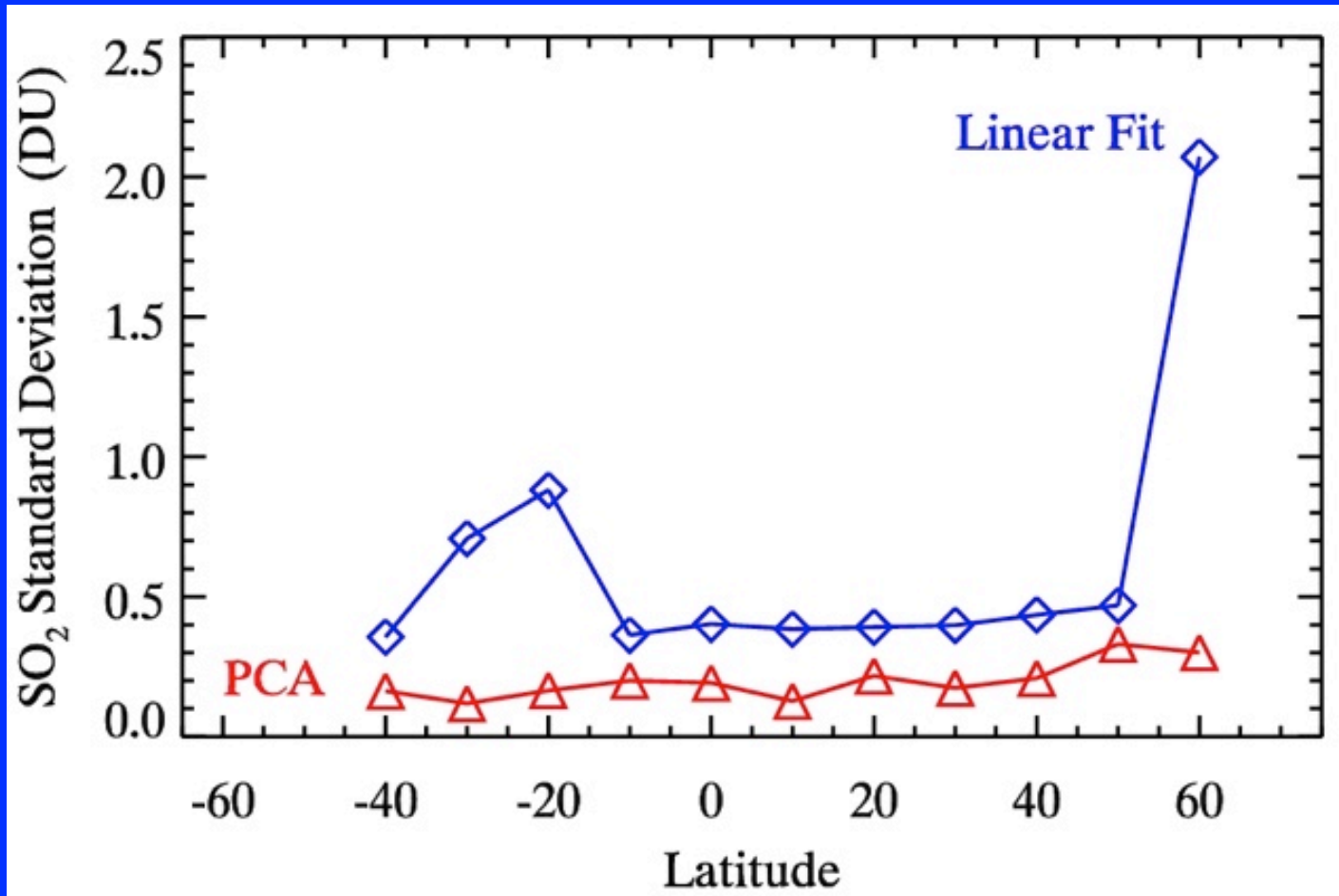
TRL Retrievals, August 5, 2006 [*Li et al.*, 2016]

# New OMI Operational Volcanic SO$_2$ Greatly Reduces Low Bias in LF Product for Large Eruptions

Kasatochi eruption in August 2008, new estimated loading ~1700 kt, in much better agreement with other estimates [*Li et al.*, 2016] . LF algorithm ~100% low bias.

New OMI Operational Volcanic SO$_2$ Greatly Reduces Low Bias in LF Product for Large Eruptions
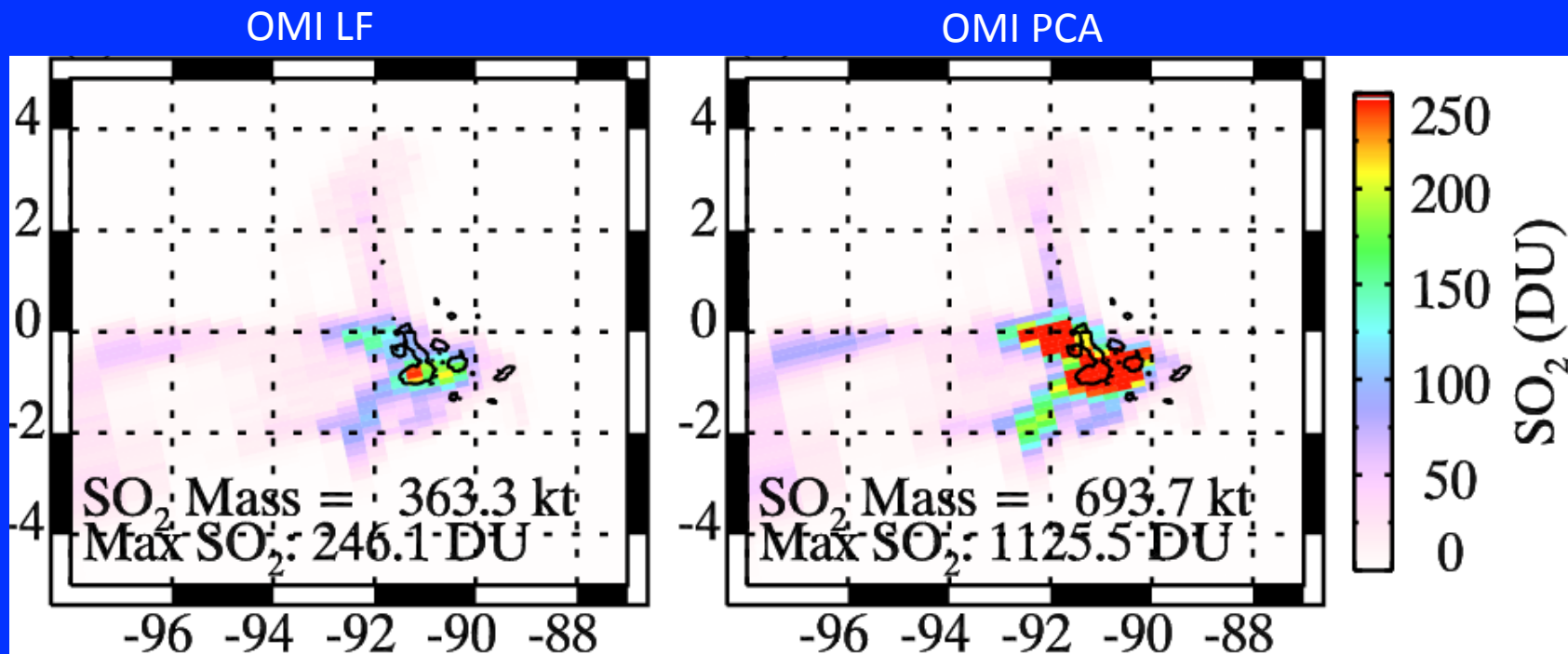

Sierra Negra eruption in 2005, max SO$_2$ from new operational PCA algorithm ~1100 DU, in agreement with the offline ISF algorithm [*Li et al.*, 2016]

Daily OMI/OMPS regional volcanic SO$_2$ loading near Hawaii (PCA 3-km/TRL retrievals)
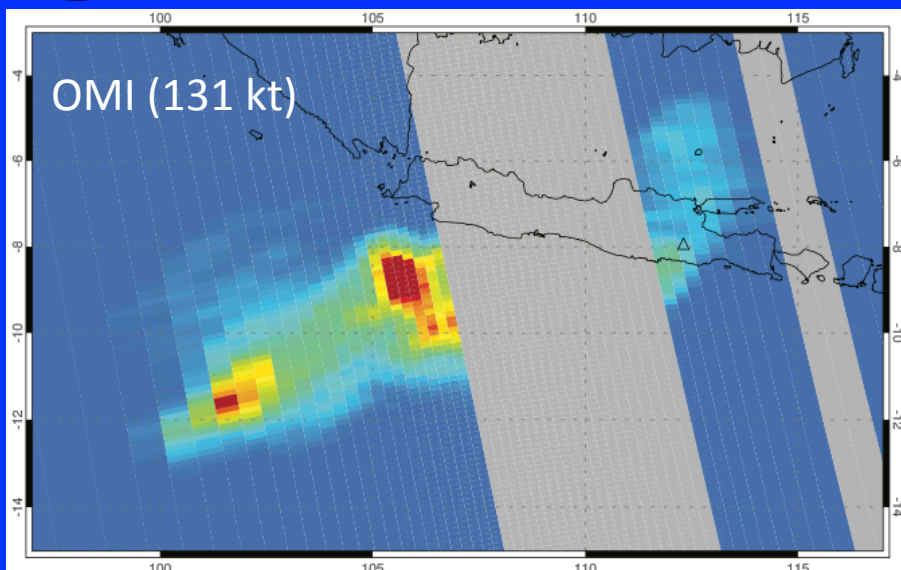

[*Li et al.*, 2016]
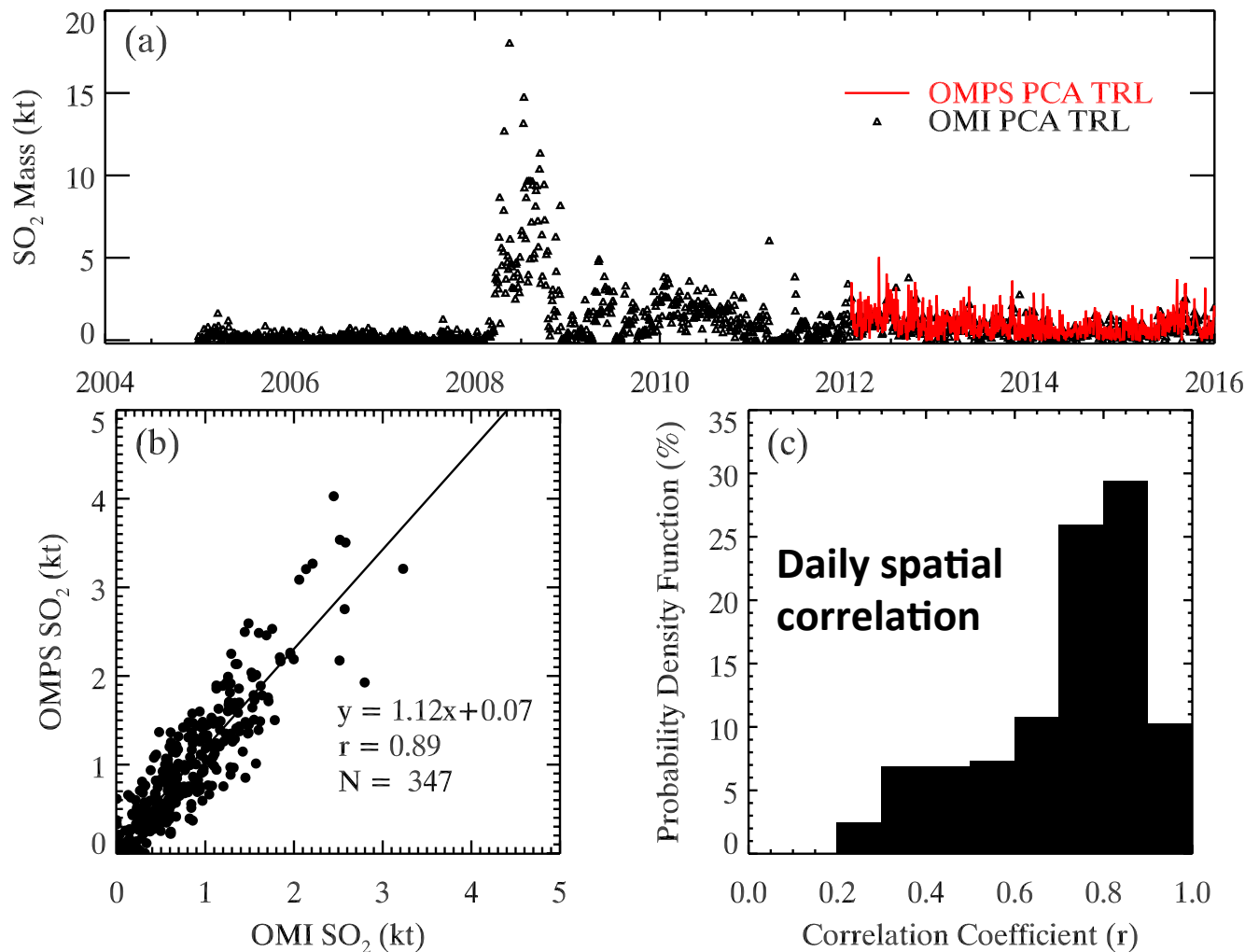
Five days with *r* < 0.3, why?

✓ Five days with *r* < 0.3: 02/05/2012, 10/02/2012, 05/14/2013, 11/06/2013, and 11/09/2014.
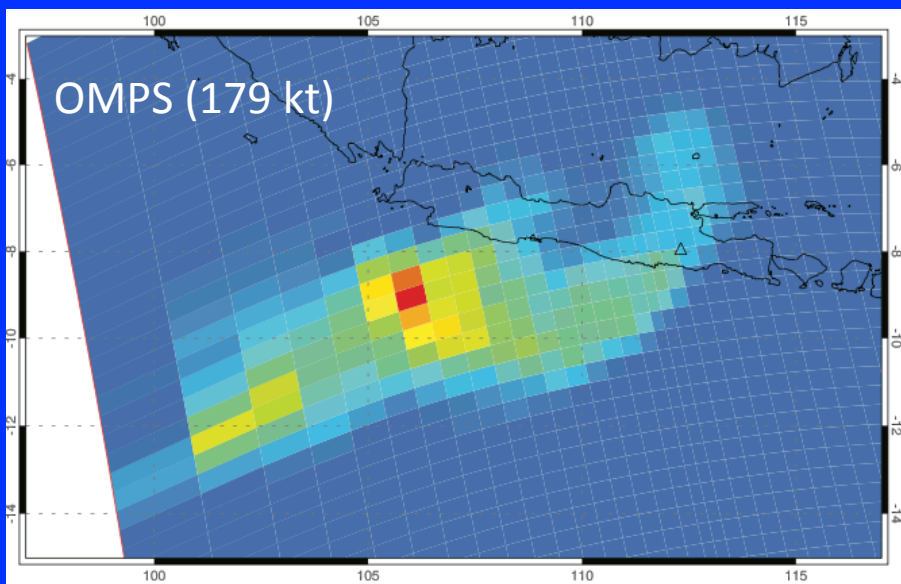✓ For all five days, the plume was covered by OMI pixels near the nadir but by OMPS pixels near the edge of the swath.
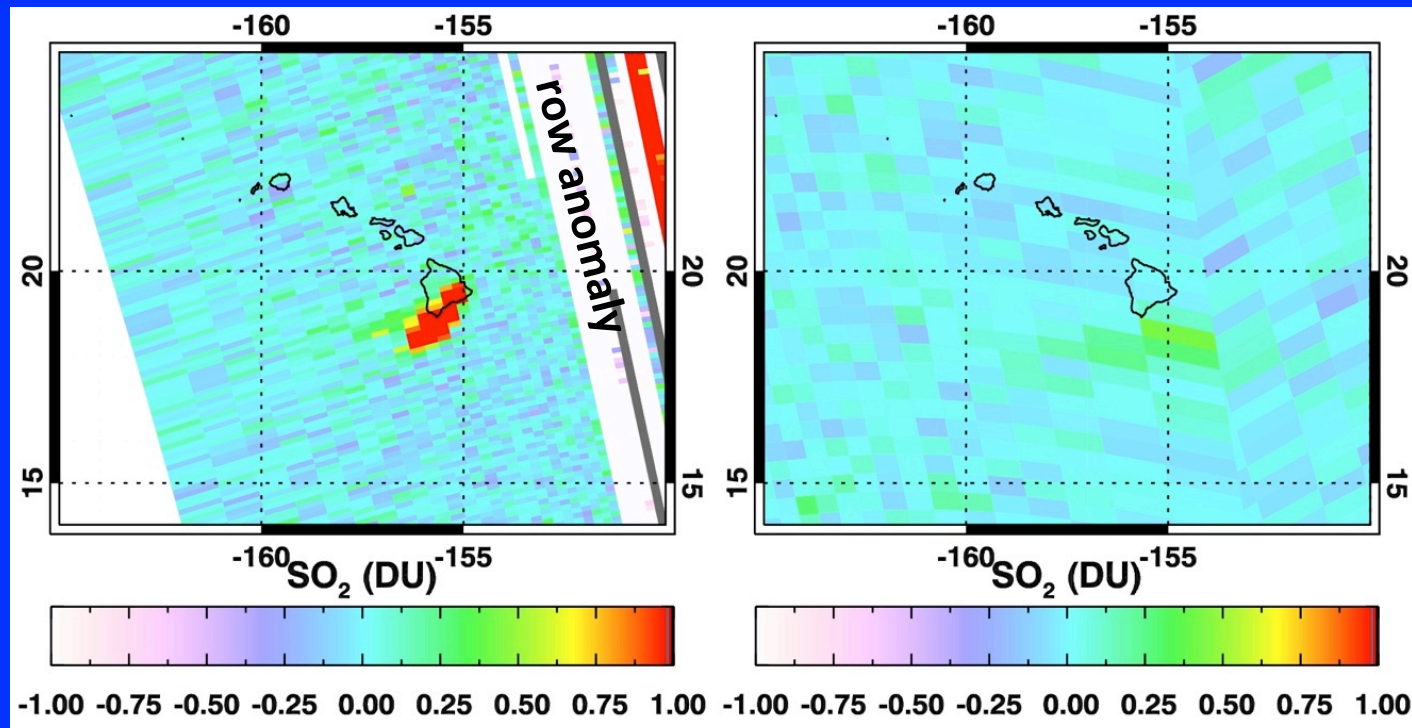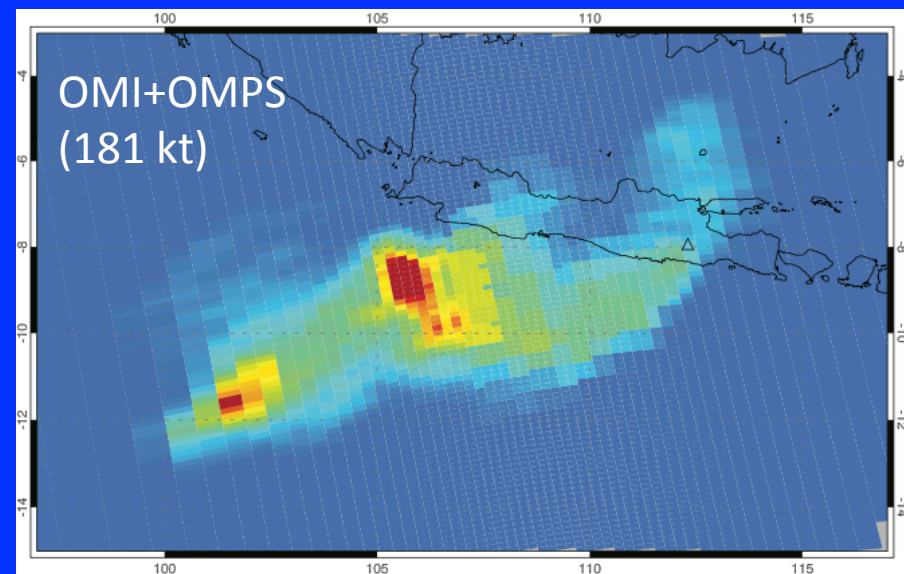

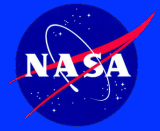**11/06/2013**

Large Eruption: Kelut in 2014

OMI (131 kt)

OMPS (179 kt)

OMI+OMPS (181 kt)

✓ **Merged OMI+OMPS provides full coverage and fine spatial detail**
✓ **Agrees with OMPS only SO$_2$ mass to within 3%**

[*Li et al.*, 2016]

Conclusions

- New generation OMI volcanic SO_2 data product – based on PCA approach, publicly released in June 2016.

- Significant improvement over the previous product – 1) reduced noise/artifacts; 2) reduced low bias for large eruptions

- Very good consistency between new OMI volcanic SO_2 data and OMPS research product based on the same PCA algorithm – good data continuity from OMI to OMPS.

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